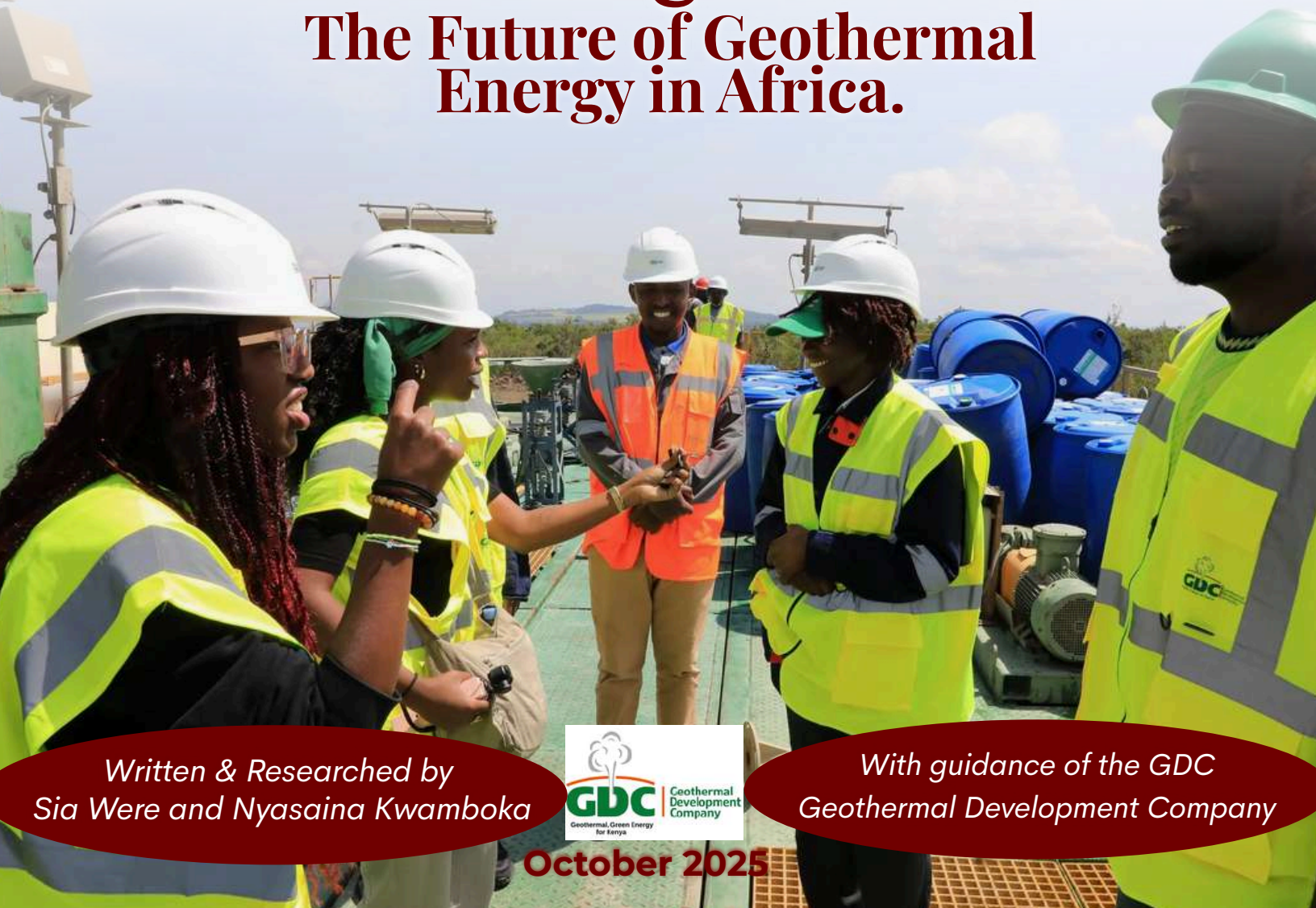
African Environmental Youth Advisory

The Menengai Geothermal Power Project & The Future of Geothermal Energy in Africa.



Written & Research by
Sia Were and Nyasaina Kwamboka

With guidance of the GDC
Geothermal Development Company

GDC Geothermal Development Company
Geothermal, Green Energy for Kenya

October 2025

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THANK YOU...

To Paul K Ngugi, CEO of the Geothermal Development Company, for honoring our invitation to explore the Menengai Geothermal Project. Through this, we had a once-in-a-lifetime opportunity to witness the energy advancements of our nation. We truly appreciate the hospitality of the GDC team that hosted our visit and has maintained contact by offering guidance as we completed this report.
To Anzetse Were, thank you for empowering us to consistently follow our dreams. Thank you to our professors who have endowed us with the knowledge that has been a catalyst for our endless curiosity.

From Nyasaina Kwamboka and Sia Were

MAIN ACRONYMS

AEYA	African Environmental Youth Advisory
Co2	Carbon dioxide
EGS	Enhanced Geothermal System
GDC	Geothermal Development Company
GHF	Geothermal Heat Flux
GW	Gigawatt
IPP	Independent Power Producer
MW/MWe	Megawatt
SGS	Steam Gathering Systems

MEET THE TEAM

Sia Were
Environmental Scientist
AEYA Junior Advisor

Sia Were is an environmental scientist with a focus on geological and regulatory matters involving the energy, agricultural, and infrastructural industries.
She completed an undergraduate dissertation in Environmental Science on '*A Comparative Analysis of Geothermal Energy in Kenya and California*' (read more here). She is also passionate about the climate change scene. Thus, she is currently working as a Junior Fellow at Carnegie Endowment for International Peace under their Sustainability, Climate, and Geopolitics program.
It was Sia's dream to visit the Geothermal Development Company (GDC) Menengai project, and through a collaborative effort with AEYA and GDC, we made it come true!

Nyasaina Kwamboka
Environmental Economist
AEYA Founder & Senior Researcher

Nyasaina Kwamboka is an economist and environmental researcher with a passion for education and amplifying transformative climate solutions. Her undergraduate research included a faculty-led 10-year carbon neutrality plan where she focused on solar energy, a science seminar on geothermal energy, and policy recommendations for the Basel Convention on Transboundary Waste.
She interned at the Environmental Defense Fund, where she learned the value of coalition building with policy makers, businesses, and academic institutions. The African Environmental Youth Advisory attracts brilliant minds with interdisciplinary expertise and is building an educational database that contributes to this progress." - Nyasaina Kwamboka (nee-yah-sayee-na kwam-boh-kah)

MEET THE TEAM

GEOTHERMAL DEVELOPMENT COMPANY

African Youth Environmental Advisory at Menengai with GDC Team (Wachira, 2025)

The Geothermal Development Company (GDC) is fully government-owned in Kenya's energy sector.

A huge thanks to:

- Managing Director & CEO, **Paul K. Ngugi**
- Senior Engineer, **Esther Njuguna**
- Senior Engineer, **George Muriga**
- Drilling Operations Engineer, **Doughty Musalia**
- Communications Marketing Officer, **Duncan Wachira**
- Environmental Scientist, **Festus Mbae**
- Direct-Use Agricultural Expert, **Justus Nyongesa**

SOSIAN ENERGY

Sosian Energy Limited is dedicated to transforming Kenya's energy sector by utilizing clean, renewable, and sustainable energy sources. They are an independent power producer (IPP), specializing in geothermal, wind, and solar energy, providing a reliable and environmentally friendly electricity supply to the national grid.

A huge thanks to:

- Sosian Mechanical Engineer, **Chakravarthy Potnuru (Chakri)**
- Sosian Community Liaison Officer, **Philemon Kimeli (Ole)**

African Youth Environmental Advisory at Menengai with Sosians Energy Team (Wachira, 2025)

FOREWARD

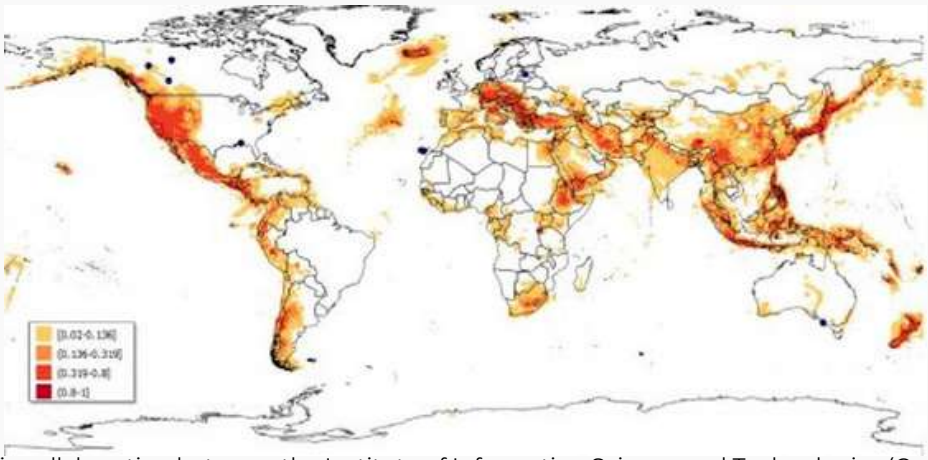
Dear Reader,

Geothermal energy is for the present. This is an educational research report designed to equip young minds with knowledge about green, renewable energy resources, in particular geothermal energy, which harnesses energy from radioactive decay stored deep within our Earth's crust. In partnership with Geothermal Development Company (GDC) and Sosian Menengai Geothermal Power Ltd, we invite you to take a close look at the Menengai Geothermal Prospect in Nakuru, Kenya.

This report explores the local value of geothermal energy and the various ways young Africans can get involved.

Our in-depth geothermal energy analysis explores socioecological and technical framing and examines these patterns. We aim to amplify the value of investing in the geothermal industry in African nations.

We seek to empower readers with the knowledge necessary to advocate for sustainable practices and solutions in the fight against energy inaccessibility, using a case study in Kenya's Menengai geothermal prospect. We hope this report encourages more people to join us in advocating for policy changes and innovative solutions that will safeguard our planet for future generations. Every effort counts!

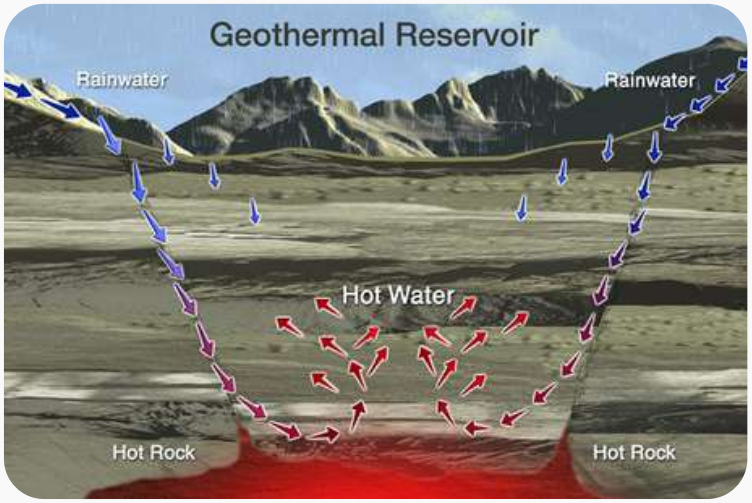


Under a scientific collaboration between the Institute of Information Science and Technologies (Cnr-Isti) and the Institute of Geosciences and Georesources (Cnr-Igg), researchers have created a global map, showing suitability of an area for the installation of a highly efficient geothermal power plant. (source: CNR)

INTRODUCTION

WHAT IS GEOTHERMAL ENERGY?

To trace it back to the root meaning: 'Geo' meaning earth, and 'thermal' meaning heat. In *The Physics of Energy*: "Thermal energy within the planet is continuously replenished by the release of energy through decay of radioactive isotopes... Thermal energy released to the Earth's surface through hot springs and other geothermal features has been used for warmth for many cultures for thousands and thousands of years" (Jaffe & Taylor, 2018). Hence, geothermal energy, which translates to heat from the Earth, is a renewable source of energy that is recyclable and has minimal environmental impact, resulting in far less CO2 emissions because it optimizes heat generated internally (the Earth's very hot interior) and externally (solar energy from the isotropic radiative decay on the Earth's exterior and partial interior –the crust and mantle).



Variation of Temperature in Earth's Crust (Kumar et al., 2020).

Geothermal Heat Flux

The average global rate of geothermal heat flux is

$$\bar{q}_{geo} \cong 87 \text{ mW/m}^2 .$$

Some of this is energy from radioactive decay of elements in Earth's crust, while some is residual thermal energy in the planet's interior from gravitational energy released during Earth's formation. The rate of heat flow is higher through oceanic crust than through continental crust and highest through freshly formed crust, and near plate margins and *hotspots*.

Image of the geothermal heat flux (GHF) (Jaffe & Taylor, 2018).

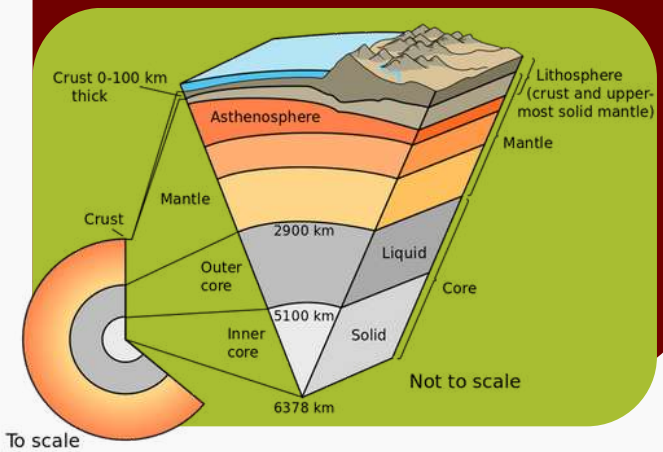
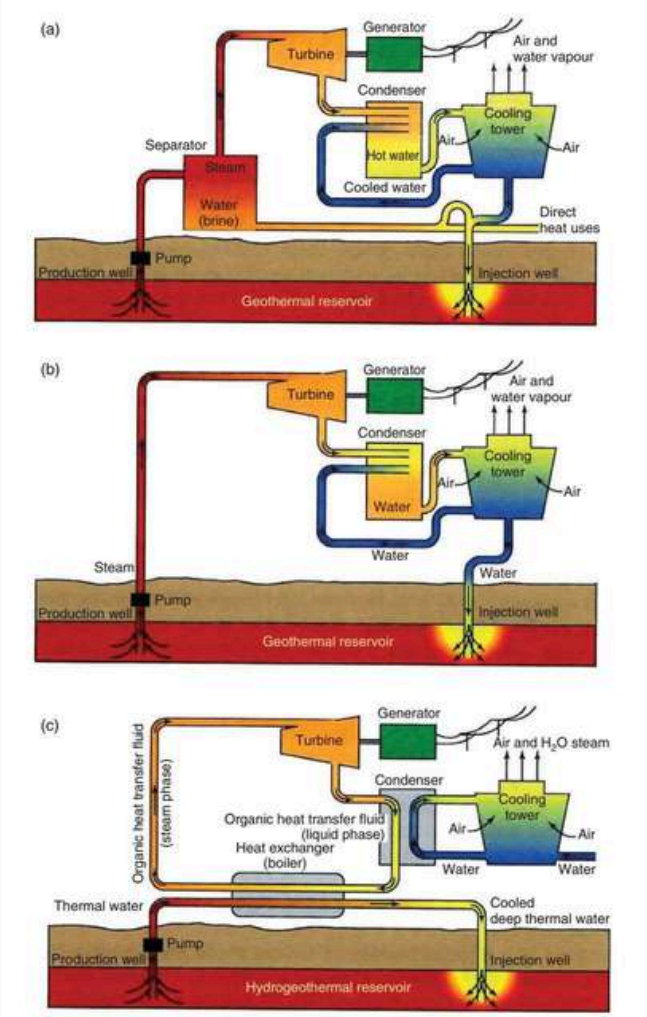


Image of the Earth's layers (Geiger, 2019).

Geothermal energy is the utilization of ground source heat pumps to transfer thermal energy from radioactive heat production from Earth's crust isotopes, such as uranium (238U, 235U), thorium (232Th), and potassium (40K), for instance, as means and to turn turbines and produce electricity.

INTRODUCTION

TYPES OF GEOTHERMAL POWER PLANTS



Process diagrams for geothermal power plants using (a) flash steam; (b) dry steam; (c) binary (Fawzy, 2020).

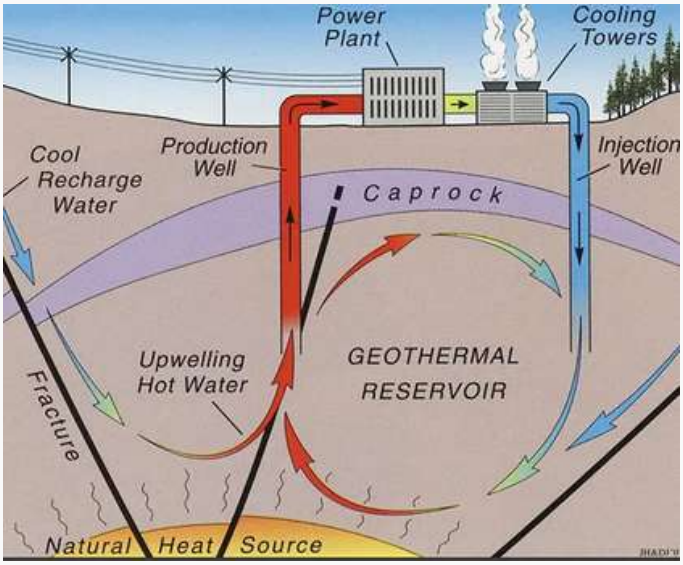


Image of Next Gen Geothermal: Hydraulic fracturing or EGS (Illuminem, 2023).

a **Flash Steam Power Plant**
Most plants in Kenya use flash steam at temperatures above 130°C (Ibrahim Kipngeno Rotich et al., 2024). The water is channeled into a flash tank with a much lower pressure than the well (Commission, 2025). This sudden pressure drop causes some of the hot water to boil and turn into steam. At the surface, the reduced pressure causes some of the water to turn into steam ("flash") rapidly (How Geothermal Power Plants Provide Clean Energy | Geothermal Rising: Using the Earth to Save the Earth, 2022). This force then drives a generator turbine, and the leftover water is reinjected into the reservoir to create a renewable loop system.

b **Dry Steam Power Plant**
Here, hydrothermal fluids, mainly steam, are found naturally from within the Earth. This is where high-pressure steam is directly drilled into because it is dominated by naturally occurring steam. According to Mondejar and Chamorro (2017), "From the thermodynamic point of view, dry steam systems provide the greatest amount of energy per kilogram of fluid extracted for conversion to electricity."

c **Binary Power Plant**
Closed-Loop Geothermal Systems
Here, it uses the Organic Rankine Cycle (ORC) to generate electricity from low-temperature heat sources, like geothermal resources, by boiling a low-boiling-point organic fluid that then drives a turbine. In this closed-loop system, the heat from the source is transferred to the working fluid without mixing, providing a sustainable and less corrosive method for power generation that allows for wider application of geothermal energy. Binary and closed-loop technology shall be the future next generation of geothermal energy because "Binary cycle power plants are closed-loop systems and virtually nothing (except water vapor) is emitted to the atmosphere" (Binary Cycle Power Plant, Open Energy Information, n.d).

INTRODUCTION

HISTORY OF GEOTHERMAL ENERGY

1904	General Geothermal Energy was first harnessed in Italy by Prince Piero, but its growth was slow because of cheap competition for sources of electric power.
1960	The first geothermal power plant in the United States was operated at the Geysers in Sonoma County, California.
1956	Exploration was first started by drilling two wells in 1956 in Olkaria I, and was followed by increased interest in the 1970s.
1969	Geothermal exploration began in Ethiopia
1981	Geothermal production began in Kenya at Olkaria when the first 15 MWe generating unit was commissioned in June 1981, and the second 15 MWe was commissioned in November 1982.
1982	The Kenyan government passed the Geothermal Resources Act, establishing a legal framework for geothermal energy development.
1985	Olkaria's third unit was commissioned in March 1985, raising the total installed capacity at Olkaria to 45 MWe.
1998	Drilling of three exploratory wells at Olkaria IV was done between 1998 and 1999. Thereafter, six appraisal wells were drilled at the prospect.
1998	The Aluto–Langano Geothermal Power Station was commissioned as Ethiopia's first geothermal power plant
2007	KenGen began exploring and drilling the Menengai geothermal wells in Nakuru, Kenya

Mutinda, Peter. Title: An Overview of Geothermal Energy in Kenya Department of Electrical and Information Engineering. University of Nairobi, 2009. Link: https://eie.uonbi.ac.ke/sites/default/files/cae/engineering/eie/AN%20OVERVIEW%20OF%20GEOTHERMAL%20ENERGY%20IN%20KENYA-PROJECT.pdf

INTRODUCTION

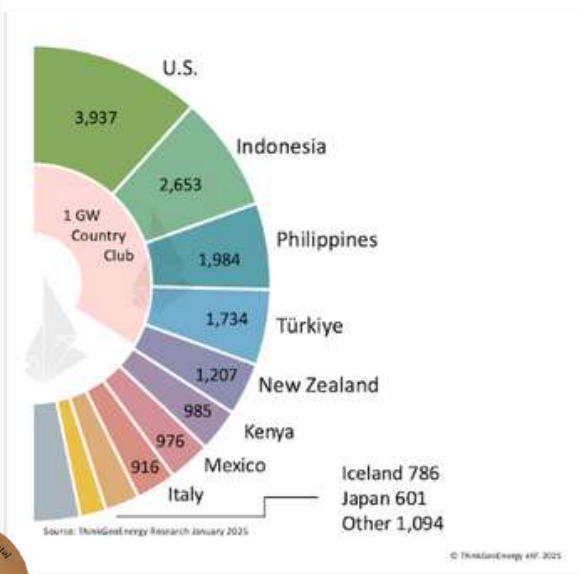
GEOTHERMAL POTENTIAL ACROSS THE RIFT VALLEY

Geothermal hotspots are not found everywhere; they are tied to plate boundaries where such as subduction zones, rift valleys, and mid-ocean ridges. They are found in the Pacific Ring of Fire, the East African Rift Valley, the Mid-Atlantic Ridge, the Mediterranean-Asian Belt, and hotspots (Coro & Trumpy, 2020).

The East African Rift System (EARS) countries have more than 20,000MWe estimated geothermal energy resource potential. There are 13 countries (Burundi, Comoros, Democratic Republic of Congo (DRC), Djibouti, Eritrea, Ethiopia, Kenya, Madagascar, Malawi, Mozambique, Rwanda, Tanzania, and Uganda) in the EARS, where the heat energy from the interior of the earth escapes to the surface. (Abegaz, 2017)

Credit: Gall-Peters Projection Map Wikipedia
Geothermal hotspots added for context by AEYA.

Kenya leads Africa in geothermal electricity production and ranks sixth globally, just behind New Zealand (1,029 MW). The United States is the top producer at 3,900 MW (Think GeoEnergy, 2025).



Global geothermal electricity production by country (MW). Data from ThinkGeoEnergy Research, January 2025.

Geothermal energy holds a huge opportunity for African youth, as our continent has the potential to produce 20,000 MW. And as of 2025, only 5% of this energy has been tapped into, 985 MW in Kenya and 7MW in Ethiopia. We have untapped energy technological advancement, and this is an opportunity for job growth while addressing the foundational energy gaps on the continent.

KEY FACTS: GEOTHERMAL FIELD

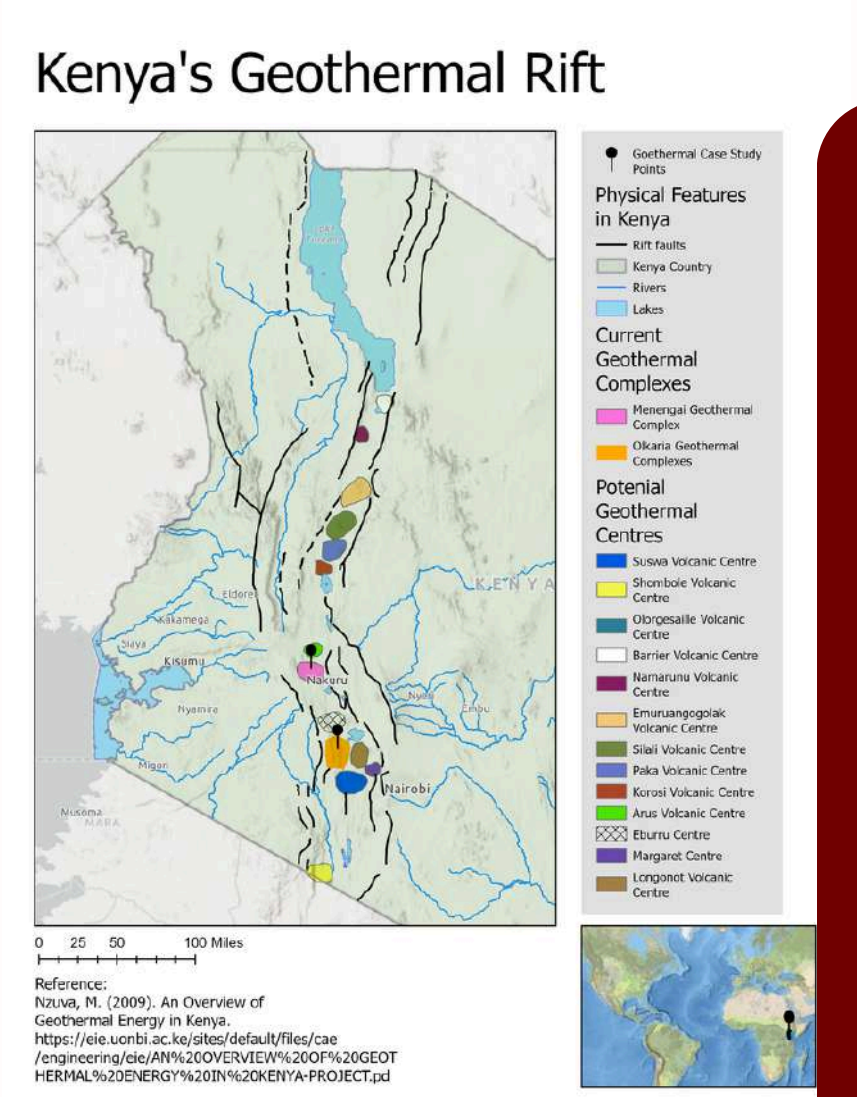


Image of Kenya's Geothermal Rift (Were, 2025).

Kenya's geothermal potential is estimated at 10,000 MW (Brown, 2022). This is particularly profound in the Kenyan Rift Valley (see the map on the left). To better situate the figure: "The country has exploited close to 950 MW of geothermal energy so far, enough to power about 3,800,000 homes, through a combination of state and private commercial projects" (Brown, 2022).

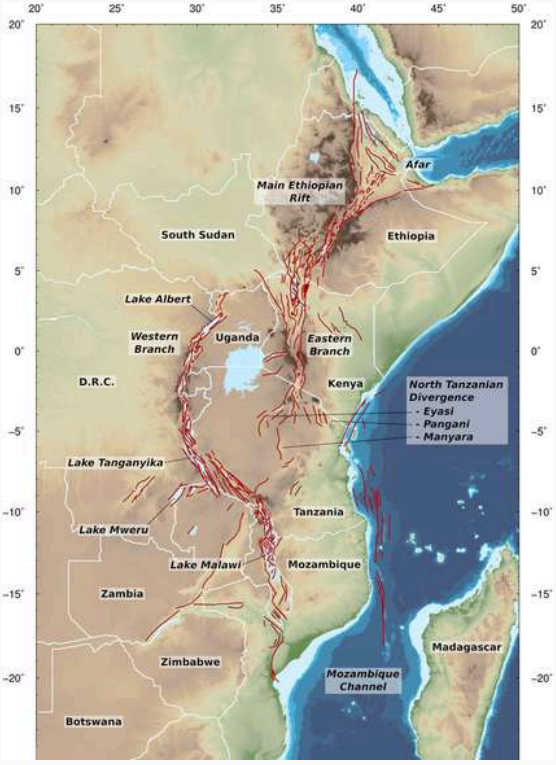
Kenya produces the most geothermal energy in Africa. What is more, "Kenya inches closer to joining the '1 GW Club,' with progress at Menengai and other projects" (Cariaga, 2025). Why? Well, Kenya is located in a volcanic hotspot of sorts. Kenya's Geothermal Rift is part of the East African Rift system (EARS), where tectonic plate divergence of the African plate and the Somalian plate creates thin crust and near-surface volcanic activity, allowing for the tapping of subterranean heat, and this is a major geothermal resource.

"Tucked away in remote, sun-scorched volcanic zones, Kenya's geothermal operations might seem peripheral. But they are, in fact, at the centre of the global green energy conversation. With a current installed capacity of 985 MW—making up nearly 45 % of the national electricity supply—Kenya ranks sixth globally in geothermal power generation. An impressive 93 % of the national grid is now powered by renewable energy, with geothermal as its anchor. In the arena of environmental diplomacy, this gives Kenya rare credibility. "

— Geothermal Development Company (Wamanji, 2025)

WHY GEOTHERMAL ENERGY MATTERS FOR AFRICA'S YOUTH AND CLIMATE FUTURE

1. The East African Rift spans 10 countries, extending from Eritrea to Mozambique. This presents an opportunity for geothermal energy to serve as the foundation for regional energy cooperation, such as a shared East African power pool. A power pool is an agreement to share electricity across national borders. If one country has an oversupply of electricity and another has a shortage, the surplus country will export its electricity to balance the deficit.



Map of the East Africa Rift System (EARS). White lines show national borders. Red lines show recently active faults, (Craig & Jackson, 2021).

We have an existing South African Power Pool established in 1995, an East African Power Pool established in 2005, and a West African Power Pool established in 2006. This framework is critical for young Africans because our continent has the youngest and fastest-growing population in the world. As the population increases, so does the electricity demand. Power pools matter because we need electricity for businesses, manufacturing industries, and digital access. Having more reliable and affordable electricity reduces the cost of living, and should remain a key policy priority.

THE YOUNGEST AND FASTEST GROWING POPULATION IN THE WORLD.

> "Every megawatt generated locally replaces a need to import fossil fuels saving Kenya precious foreign exchange. It is this indigenous energy source, abundantly on Kenyan soil, that also holds the key to powering the nation's industrial ambitions."
>
> *Geothermal Development Company 2025 Special Report*

WHY GEOTHERMAL ENERGY MATTERS FOR AFRICA'S YOUTH AND CLIMATE FUTURE

2. **We are forced into blackouts and candlelit homes when we have untapped energy beneath our feet.** Our continent has an estimated 15,000–20,000 MW of geothermal potential, and currently, we use less than 1000MW. We must encourage more government and private company initiatives to advocate for more intentional policy advancement and investment into geothermal energy. Unclear policy regulatory framework has been a consistent hurdle as there have been disputes among developers, policymakers, and local communities as seen in Prospects and Challenges of Geothermal Energy in Uganda by Mutumba Geoffery et.al 2021, Djibouti is in the process of creating one owing to delays caused by various challenges, including the lack of political awareness among political leaders stated by Abdi Mahammoud et.al 2024.

Together, we must work on transforming our energy landscape by engaging with current field experts and empowering an expansive geothermal energy revolution. If you are an engineer, lawyer, financial expert, or a frontline community member, use your background to innovate actionable plans to inspire progress within this space.
Geothermal projects need engineers, geologists, policy experts, data scientists, community organizers, and technicians. Therefore, we have an opportunity to dedicate our careers to these fields.

WE MUST TRANSFORM OUR ENERGY LANSCAPE

ENGINEERS AT A GEOTHERMAL DRILLING SITE (WACHIRA GDC 2025).

MENENGAI EDITION

OVERVIEW OF THE MENENGAI GEOTHERMAL PROJECT

Geothermal development and utilization is a key component in the global transition towards sustainable, low-carbon energy systems. It is a foundation for a world where reliable power coexists with the protection of our planet. The future generation of clean energy technologies is not only an environmental necessity but also a call to responsibility, a call to lead with courage, vision, and purpose. By championing these innovations, we will not only safeguard our communities but also redefine progress: creating societies that are resilient, economies that are inclusive, and a planet that thrives for generations to come. As future leaders, we are not just participants in this transition, we are the driving force, the engine of resilience, and the stewards of tomorrow's energy landscape. Geothermal – always available, reliable and a constant reminder that the power to build a sustainable future is right below our feet!

ENGINEER ESTHER NJUGUNA

GDC Geothermal Development Company
Geothermal, Green Energy for Kenya

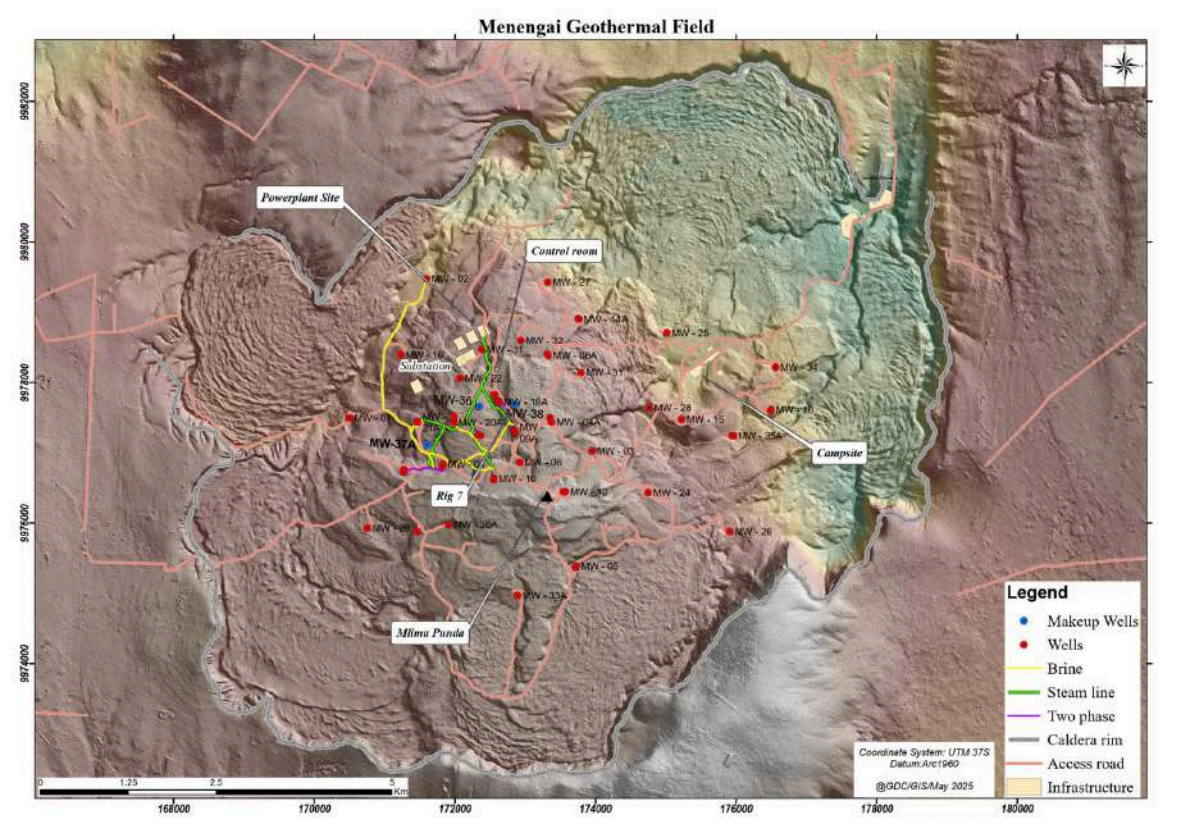
MENENGAI EDITION

OVERVIEW OF THE MENENGAI GEOTHERMAL PROJECT

Menengai is located in Nakuru County. This is about 20km or three hours northwest of Nairobi, the country's capital city. Here, found in the Kenyan rift valley, a volcano the size of about 14 square km erupted a long time ago. According to the Smithsonian, the last eruption was 6050 BCE (or 8074 years ago) (Global Volcanism Program | Menengai, n.d.). In the case of Menenagi, the tip collapsed within itself and formed the Caldera we call Menengai. The name "Menengai" originates from the Maasai language, meaning "the devil's place" or "the dead", comes from observing strange phenomena of "smoke" rising from the ground which was the steam from the fumaroles was believed to be the souls of these dead warriors.

GDC began operations in Menengai between late 2009 and early 2010, specifically. The first well was installed in February 2011 (source Eng. Doughty) to the present, whereby deep geothermal wells have been dug to harness the steam and other resources; three power plants combined will deliver 105MWe of electricity to Kenyans.

DIAGRAMS OF MENENGAI GEOTHERMAL FIELD

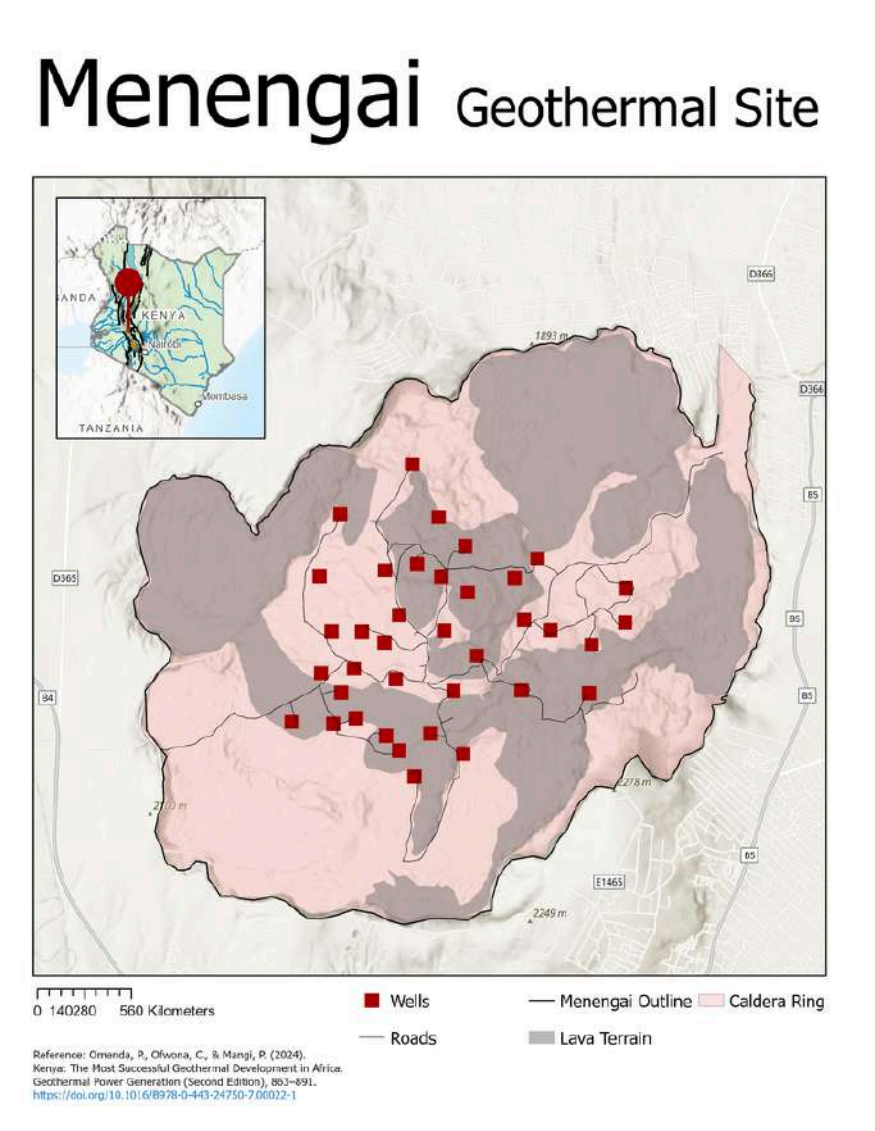


Map of the Menengai Geothermal Field Station (GDC)

WHAT WE LEARNED AT MENENGAI

CALDERA EXCAVATION

"Surface geology suggests that Menengai has had a recent volcanic activity marked by the lava flow mapped at the central area that issued from the E-W fissure. The south of the caldera has also been active in recent past based structures and evidence of volcanism in this area namely eruption cones, young lava flowing into the caldera from the outer rim. Therefore, the central and south of the caldera are interesting areas for further geothermal exploration. From borehole geology there is a shallow magma at the centre of the caldera, this is heat source driving the system here hence the up flow as inferred from geochemistry located at this zone.
(Mibei, 2016)



Map of Menengai Geothermal Site (Were, 2025)

MENENGAI EDITION

WHAT WE LEARNED AT MENENGAI

During our field trip to Kenya's Geothermal Development Company (GDC) Menengai project, we toured five distinct areas:

1. **Caldera excavation**
2. **Drilling rig operations**
3. **Main Control Room**
4. **Power plant generation - Sosian Menengai Geothermal Power Ltd**
5. **Menengai Direct-Use Pilot Project**

This portion of the report aims to delve deep into the 5 areas we visited.

CALDERA EXCAVATION

WE BEGAN WITH AN EXPLANATION OF THE CALDERA, FOUND IN MENENGAI, BY OUR LEAD EXPERT, SENIOR ENGINEER ESTHER NJUGUNA (WACHIRA, 2025)

WHAT IS A CALDERA?

A caldera is a depression created after a volcano partially collapses after releasing the majority of its magma chamber in an explosive eruption. The Menengai Geothermal Project is situated within the Menengai Caldera, also referred to as the Menengai Crater. The Menengai volcano erupted about 8,000 years ago, in 6050 BCE (Global Volcanism Program, 2025), meaning it has become a natural geothermal resource today.

Nyasaina Kwamboka at Menengai Caldrea site (Wachira, 2025)

WHAT WE LEARNED AT MENENGAI

DRILLING RIG OPERATIONS

FACTS

1. Owned rigs: As of 2025, GDC's strategy is to use its own drilling rigs to reduce costs. In the past, GDC's analysis showed that using owned rigs cost about $3.5 million per well.
2. Hired rigs: The same analysis found that hiring rigs was nearly double the cost, at approximately $6.5 million per well.
3. GDC Menengai operates more than 40 wells with 85% actively producing steam (Eng. Doughty, 2025).
4. For drilling rigs for large-scale geothermal production, wells can circulate more than 3,000 liters of water per minute as part of the drilling fluid, or "mud," circulation system (Adityatama et al., 2020).
5. The project provides training and job opportunities for young engineers, technicians, and local communities, helping build Kenya's green workforce.

PRINCIPLES OF DRILLING TECHNIQUES

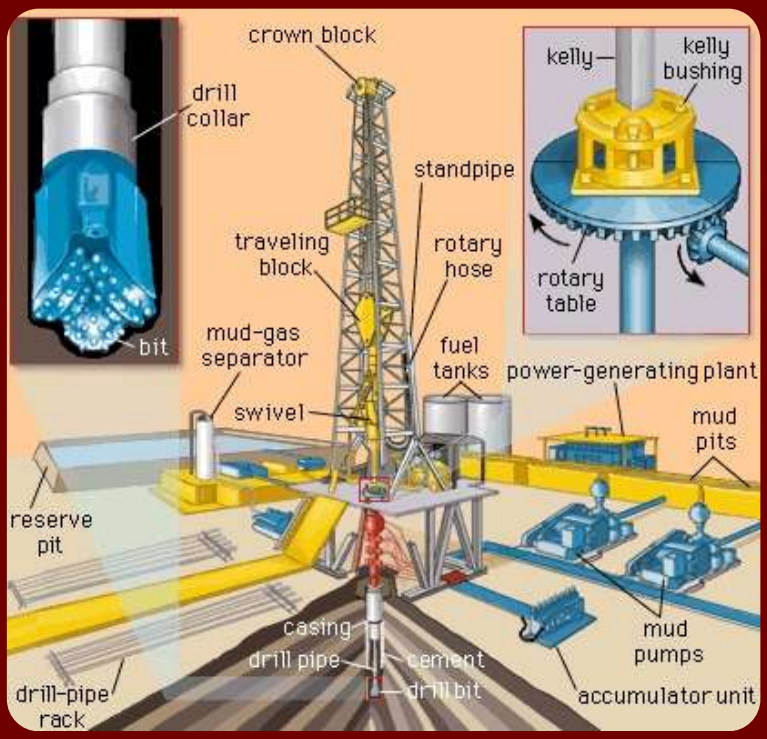


Image of Principles of Drilling Techniques (Klempa et al., 2024)

PHOTOS AT SITE

Engineer Doughty takes us through the drilling rig completion from the ruster mud to the monkey board of one of Menengai's newest wells (Wachira, GDC, 2025).

Image of well MW54 rigging operation (Were, 2025).

WHAT WE LEARNED AT MENENGAI

DRILLING RIG OPERATIONS: TIME LINE FROM SETTING UP THE RIG TO DRILLING THE WELL

1. **Site preparation (1–2 months):** The initial phase involves creating access roads and leveling the well pad, which must be large enough to accommodate the rig and other equipment.
2. **Rig mobilization and setup (1–3 weeks):** The drilling rig is transported to the site and assembled. At Menengai, GDC operates its own ZJ70D rigs, which have a maximum hook load of 4500 kN.
3. **Drilling the surface section (7–10 days):**
   a. *Activity:* A large-diameter hole (e.g., 26 inches) is drilled to a shallow depth (e.g., 80 meters).
   b. *Challenges:* The surface layers at Menengai are known to be hard and abrasive, causing vibrations and low penetration rates.
4. **Install conductor casing:** A large-diameter casing is set into the surface hole and cemented to provide stability and seal off near-surface water.
5. **Drill the intermediate section (10–15 days):**
   a. *Activity:* A smaller-diameter hole (e.g., 17½ inches) is drilled deeper (e.g., 80–400 meters).
   b. *Challenges:* Drilling through medium-hard rock and dealing with the potential for lost circulation, where drilling fluid disappears into fractured rock.
6. **Install anchor casing:** An intermediate casing string (e.g., 13⅜ inches) is set and cemented to secure the upper wellbore.
7. **Drill the production section (weeks to months):**
   a. *Activity:* A smaller hole (e.g., 12¼ inches) is drilled toward the production depth (up to 1,000 meters).
   b. *Challenges:* Incompetent formations that can collapse and require the use of special drilling muds and sweeps to prevent hole collapse.
8. **Install production casing:** This casing string (e.g., 9⅝ inches) is set and cemented to isolate the formation and provide a stable conduit for the high-temperature, high-pressure steam.
9. **Drill the final production section (weeks to months):**
   a. *Activity:* A final, smaller-diameter hole (e.g., 8½ inches) is drilled to the target depth (often 2,000+ meters) to intersect the geothermal reservoir.
   b. *Fluid:* Water or aerated water is used as the drilling fluid to avoid sealing the productive zones with mud.
10. **Install slotted liner:** A perforated liner is placed in the final section to allow steam and water to flow into the well.
11. **Well testing and monitoring (weeks to months):**
    a. *Activity:* After drilling, the well undergoes flow testing to measure its output, temperature, and pressure.
    b. *Goal:* The data helps determine the well's productivity and overall steam capacity.

WHAT WE LEARNED AT MENENGAI

DRILLING RIG OPERATIONS

"Geothermal drilling is more than just wells, its about unlocking clean energy from the earth. As future engineers, you're not just pushing the bit into the ground; you're pioneering the path to a sustainable future. Unlike oil and gas, you're not chasing a depleting resource, you're tapping into a renewable heat reservoir that could power communities for generations. The challenges are real. They range from downhole challenges such as high temperatures, hard formations, corrosive fluids, among others, to logistical nightmares. But so are the rewards. Every well you drill is a step toward reducing carbon emissions and securing energy independence. Approach it with curiosity, resilience, and profound respect for the earth because we are not just drilling engineers but rather great ambassadors pioneering energy transition from depletion and environmental degradation to a greener and sustainable shift.

ENGINEER DOUGHTY MUSALIA

GDC Geothermal Development Company

Geothermal, Green Energy for Kenya

WHAT WE LEARNED AT MENENGAI

KEY FACTS ABOUT THE GEOTHERMAL FIELD

Engineer **George Muriga** took us through the expansion of the Geothermal Development Company, explaining the practical and technical methods used to monitor and maintain geothermal production via the control room.

HOW GEOTHERMAL ENERGY IS HARNESSED (STEP-BY-STEP PROCESS)

1. From the control room, an engineer can monitor how the production wells are extracting steam through the borehole rigging system. The steam from the earth is connected to the 'steam gathering system' via pipelines.

2. The resource from the well is channeled to a vessel called a separator, where the steam is separated from the brine. The brine is channeled to a reinjection well, where, deep underground, the molten rocks will reheat the brine and circulate it to the production wells. This is why geothermal energy is renewable.

3. The steam from the separator is channeled to the power plant, where a turbine coupled to a generator produces electricity. The electricity is then supplied to the grid.

4. However, after the steam passes the turbine, it is drawn to a condenser where it has now lost its energy, is blown to the cooling tower, where it becomes condensate, which is collected and pumped to another well called the cold reinjection well.

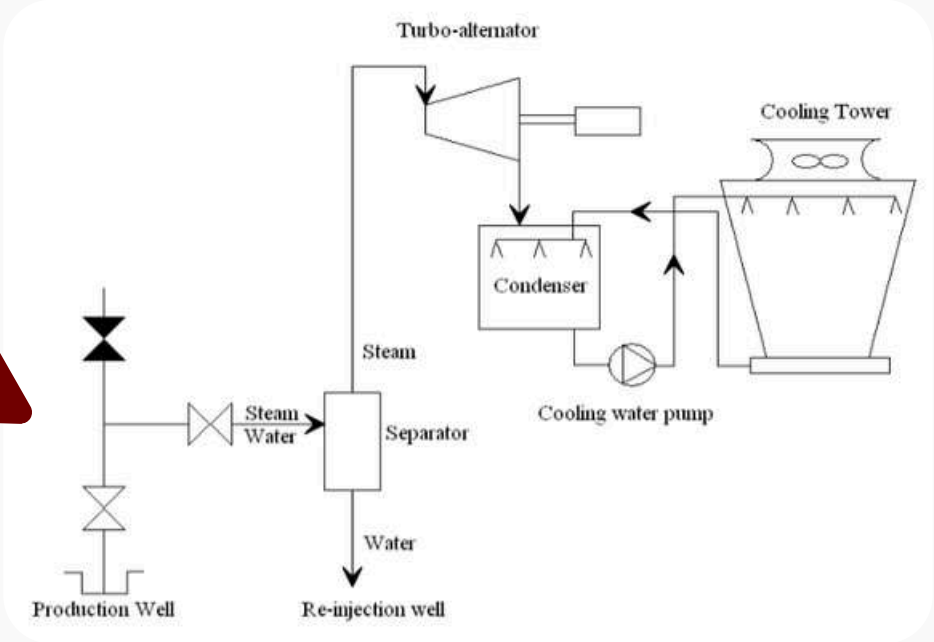


Diagram of Geothermal System from Production well to cooling Tower (GDC)

WHAT WE LEARNED AT MENENGAI

KEY FACTS ABOUT THE GEOTHERMAL FIELD

Quick facts about the Menengai Geothermal Project's Steam Gathering System

The Steam Gathering System (SGS) is a mega piping system used in geothermal projects to collect and deliver steam from the steam fields to the power plants. The system connects geothermal wells to a power plant. The pipes are overlaid with cladding material to prevent heat loss. GDC has used green as the colour for our steam gathering system as it blends the SGS with the environment and prevents habitat interference.

1200

Quantity in tons per hour of geothermal steam carried through the SGS- a capacity that is in excess of what is required for the 105MW power plants at the Menengai Geothermal Project

25

Length in kilometres of the steam gathering system at the Menengai Geothermal Project

13

Number of wells that will feed the steam gathering system for the Menengai 105 MW power plants

1

Number of control rooms needed to operate the entiire steam gathering system

Copyright (c) 2022 Geothermal Development Company

Info-grahpic of Steam Gathering System (GDC)

NEWS STRAIGHT FROM GDC

Image of AYEA members (Nyasaina and Sia) with Eng. George at GDC Menengai (Wachira, 2025)

"Development of the Menengai Geothermal Project, estimated to harbor a potential of 1600MW, was started in 2009. Surface studies have been completed and exploration and appraisal wells done.

The project will be developed in five (5) phases with the long-term goal of developing 465MW of geothermal steam equivalent. A total of 53 wells with a potential of 169MW have been drilled by 2023 so far."
(Geothermal Development Company , 2025)

WHAT WE LEARNED AT MENENGAI

MAIN CONTROL ROOM

"We engineers use earth resources to solve mankind's problems by applying scientific principles.

We always have an inquisitive mind about how this would work. A creative angle, what if we do this? Always a problem-solving mindset, all aimed at improving human living standards.

We are all-rounded, once we grasp those engineering principles, we become attuned with nature and technology, civil works meet structures, structures get paired with machines, machines meet electricity, then amazing things start happening, AI is all the buzz nowadays...

Enter geothermal, and there you'll have unlimited possibilities. As a steamfield engineer in the control room, I couldn't have a better example of the epitome of engineering!

ENGINEER GEORGE MURIGA

GDC Geothermal Development Company

Geothermal, Green Energy for Kenya

WHAT WE LEARNED AT MENENGAI

SOSIAN ENERGY LIMITED

35-MW MENENGAI GEOTHERMAL POWER PLANT

Image of 35-MW Menengai Geothermal Power Plant (Sosian Energy, 2025)

"With our flagship 35-MW Menengai Geothermal Power Plant, we are at the forefront of Kenya's transition to green energy, reducing carbon emissions and promoting economic growth. Our mission is to innovate, collaborate, and deliver energy solutions that empower communities, industries, and businesses across the nation."

Sosian Energy
A Diversified Energy Company

REVOLUTIONARY DEVELOPMENT IN KENYA'S POWER INDUSTRY

The company operates a 35-megawatt geothermal facility within the Menengai geothermal zone, establishing itself as the pioneering private electricity generator in this area. Power generation commenced in August 2023, with complete operational status achieved by November 2023. This initiative promises to strengthen national electricity supply, enhance grid reliability, and reduce energy costs for Kenyan consumers.

WHAT WE LEARNED AT MENENGAI

SOSIAN ENERGY LIMITED

35-MW MENENGAI GEOTHERMAL POWER PLANT

OBJECTIVES POWERING KENYA'S SUSTAINABLE FUTURE

Sosian Energy Powers Kenya's Green Energy Transformation
Kenya continues advancing its renewable energy agenda as Sosian Energy Limited begins delivering power to the country's electrical grid. This development represents a crucial milestone in Kenya's shift toward clean energy alternatives and demonstrates the nation's dedication to environmental sustainability while decreasing dependence on conventional fuel sources (Sosian Energy Limited, 2025).

Leveraging Kenya's Natural Geothermal Resources
As a global frontrunner in geothermal power generation, Kenya benefits significantly from Sosian Energy's additional capacity. Geothermal power represents a dependable, renewable, and eco-friendly energy source that perfectly addresses Kenya's expanding electricity requirements. (Sosian Energy Limited, 2025)Through geothermal utilization, Sosian Energy supports environmental protection efforts while helping minimize national greenhouse gas emissions.

Effects on Power Distribution and Economic Development
The 35-MW Sosian Menengai facility is projected to serve the electricity needs for numerous residential and commercial establishments, enhancing access to dependable and cost-effective power (Sosian Energy Limited, 2025). This project also stimulates Kenya's economic expansion by drawing investment, facilitating industrial development, and generating jobs within the energy industry.

Dedication to Clean Energy Solutions
Sosian Energy Limited's vision extends beyond geothermal power to include other renewable technologies like wind and solar energy. The organization seeks to broaden Kenya's energy portfolio, minimize reliance on traditional energy sources, and serve as a key contributor to the country's environmental objectives.

Future Prospects
The successful launch of the Sosian Menengai facility represents only the initial phase of the company's broader mission. Sosian Energy remains dedicated to advancing clean and effective energy technologies, collaborating with industry partners, and fostering innovation within the renewable sector. As Kenya progresses toward environmental sustainability, Sosian Energy Limited leads the way in supplying eco-friendly power solutions to the country (Sosian Energy imited, 2025).

WHAT WE LEARNED AT MENENGAI

SOSIAN ENERGY LIMITED

"As a mechanical engineer – Engineers will hold tools to shape a sustainable future. Every challenge that you handle in clean or renewable energy is an opportunity to innovate, push the limits, and creating an impressive impact on the world. Your creativity, knowledge, passion, and hard work can boost future solutions. Hence, never stop learning and make sure to build a great career at the same time."

POTNURU CHAKRAVARTHY

MECHANICAL ENGINEER

Sosian Energy
A Diversified Energy Company

WHAT WE LEARNED AT MENENGAI

MENENGAI DIRECT USE PILOT PROJECT

DIRECT USE

A multi-tier approach utilising cascading heat technology that captures geothermal water at its highest temperature for demanding thermal applications, then channels the progressively cooling water through successive stages for applications requiring lower temperatures.

Image of Senior Eng. Esther Njuguna, Environmental Scientist Festus Mbae, and Sia Were at GDC Menengai Direct Use Pilot Project (Wachira, 2025)

OBJECTIVES

1. **Market Viability:** To demonstrate the economic feasibility of utilizing geothermal energy directly for commercial and industrial operations (Thinkgeoenergy, 2024; Cariaga, 2022).
2. **Industrial Development:** To promote agricultural processing facilities and manufacturing enterprises that can leverage moderate-temperature thermal resources in the region (Rojas, 2015).
3. **Capital Attraction:** To draw financial backing for establishing manufacturing ventures within the Menengai industrial complex, diversifying beyond conventional electricity production (Greiner et al., 2023).
4. **Regional Prosperity:** To generate economic value and job creation opportunities throughout the geothermally abundant area (Richter, 2016a).

WHAT WE LEARNED AT MENENGAI

WHAT IS THE DIRECT-USE PILOT PROJECT?

TARGETED IMPLEMENTATION AREAS:

Post-Harvest Processing: Natural thermal resources enable cost-effective grain dehydration through specialized geothermal drying systems, substantially reducing operational expenses for agricultural producers while improving product quality and storage life (Geothermal Development Company, 2024).

Dairy Processing: Thermal energy from geothermal sources enables milk pasteurization operations utilizing steam heating technology, providing a cost-effective alternative to conventional energy sources for temperature-sensitive dairy processes (Geothermal Development Company, 2024).

Protected Agriculture: Steam-heated greenhouse structures ensure ideal growing conditions for crops year-round. production ...

... enabling controlled environment agriculture in regions with variable climatic conditions (Geothermal Development Company, 2024).

Commercial Laundering: Heated water and steam systems support industrial-scale washing and cleaning operations through dedicated geothermal laundry units, demonstrating significant potential for service industry applications (Geothermal Development Company, 2024).

Aquaculture Operations: Steam-heated pond systems in fish farming facilities accelerate growth cycles, with fish being successfully harvested from the heated aquaculture ponds (Kenya News Agency, n.d.). The project also capitalizes on horticulture farming, including the cultivation of capsicum, tomatoes, and kales (Kenya News Agency, n.d.).

WHAT WE LEARNED AT MENENGAI

MENENGAI DIRECT-USE PILOT PROJECT

"Most people think of geothermal energy for power generation only, but there is a hidden gem in this renewable resource.

A game changer, per se. See, with geothermal resources comes Direct utilization (or Direct use, as many know it), which spans various sectors, from agriculture to industry to recreation. GDC demo projects located in Menengai Caldera are a clear illustration of these applications of geothermal energy for direct use purposes.

From heating greenhouses to control humidity, to rearing fish, to post-harvest processing such as grain drying, and also value-added activities like milk pasteurization. I can assure you that this is achievable, as I work there myself. Compared to other energy sources, geothermal is quite reliable and environmentally friendly. Oh, and it's cheap too. I urge young environmentalists to champion this resource. It saves nature and brings money to the pocket.

FESTUS MBAE

DIRECT USE ENGINEER

OPPORTUNITIES FOR YOUTH INVOLVEMENT

CAREERS IN GEOTHERMAL ENERGY

Most careers in the geothermal field require necessary certifications, university degrees, and training. When a geothermal project is launched, it is often in a rural community where the majority of the population does not hold the necessary skills (Abdi et al., 2024). Developers of geothermal energy projects take years to complete a project, and they take even longer when they require funding from international sources. With new developments, the local community recognizes that there may be abundant job opportunities, but this becomes exclusionary when not everyone is eligible for a job in a geothermal project.

There are missed opportunities to increase the skills of the local community, and a preference to source already qualified staff. While not everyone in the community can be employed, in Kenya, according to the Energy Act of 2019, local governments and local communities can receive 20% and 5% of the royalties, respectively, through trust funds, and communities can claim their right to receive direct economic benefits from geothermal energy projects. (NATLEX - Kenya - Energy Act, No. 1 of 2019)

Geothermal drilling support tanks and storage units , GDC (Kwamboka , 2025)

While technical expertise is the muscle pushing us ahead, fair representation is the backbone that keeps everything aligned. Local communities deserve the right to be fairly represented and actively engaged. This is where indigenous, professionally trained mediators come in. They would be important when developers penetrate regions to establish geothermal energy projects.

Between land reallocation, employment misunderstandings, and compensation, a mediator can harmonize policymakers, developers, and native settlers. We must comprehend and respect the voice of the involved Indigenous people. Understanding both culture and conflict resolution will significantly improve the outcomes in a positive and balanced manner.

OPPORTUNITIES FOR YOUTH INVOLVEMENT

CAREERS IN GEOTHERMAL ENERGY

There are a plethora of opportunities and career paths from STEM to finance and policy.

- In physical sciences where research is explored, like hydrology, engineering, geochemistry, and geophysics, researchers would investigate innovative tools for geothermal power production.
- In fieldwork operations, drilling & wellfield operations, powerplant construction, environmental safety, technicians, manufacturing supply chains, data collection and monitoring through drones and sensors, and more
- In sales and finance, you could work as an accountant, project investment and management, operational finance, benefit-sharing, impact finance, and advising governments on finance frameworks, tariffs, incentives, and PPP policies
- In policy & law, you could focus on energy & natural resource law, land rights and compensations, local, national & international policy development, public interest law, climate finance governance, and more.

All these careers apply to the geothermal industry around the world. In short, interdisciplinary professionals are needed everywhere in geothermal development. We have attached organizational resources for you on the next page.

Sosian, Geothermal Development Company, and the African Environmental Youth Advisory at the Sosian Menengai Geothermal field (Wachira, 2025)

OPPORTUNITIES FOR YOUTH INVOLVEMENT

COMPANIES & INSTITUTIONS IN GEOTHERMAL ENERGY

THERE IS A PLETHORA OF OPPORTUNITIES FOR INTERNSHIPS, MENTORSHIP PROGRAMS, EDUCATIONAL ACTIVITIES, AND INDUSTRY PARTNERSHIPS. KINDLY EXPLORE THE FOLLOWING COMPANIES FOR MORE INFORMATION ON CURRENT OPPORTUNITIES

Geothermal drilling rig at the Menengai project site. This tall steel structure is known as a derrick. It supports the drilling equipment used to bore into the earth's crust in search of geothermal steam and hot water reservoirs (Kwamboka, 2025)

KENYA-BASED OPPORTUNITIES

Geothermal Development Company (GDC): Offers internships, research opportunities, and field experience in geothermal exploration.
Kenya Electricity Generation (KenGen): Provides industrial attachments and graduate trainee programs in renewable energy.
Akira Geothermal Company: Private company with youth-focused technical roles.
Sosian Energy: Developing geothermal projects in Kenya, open to youth engineers and researchers.

AFRICA-WIDE & REGIONAL INSTITUTIONS

African Geothermal Association (AGA): Connects youth to training, conferences, and networking across the continent.
African Union Commission – Geothermal Risks and Mitigation Facility (AU-GRMF): Supports student research and innovative geothermal projects.
Djibouti Office of Geothermal Energy Development (ODDEG): Opportunities for regional exchange and knowledge-sharing.
Oando Clean Energy (Nigeria): Expanding into geothermal and renewable projects, open to youth innovation.

INTERNATIONAL PARTNERS & FUNDING BODIES

African Development Bank (AfDB): Funds geothermal projects and offers programs for youth in clean energy finance.
Reykjavík Geothermal (Iceland): Known for international partnerships and mentorship in geothermal science.
African Renewable Energy Fund (managed by Berkeley Energy): Supports youth-led enterprises in clean energy.
Globeleg (Menengai I Project): Internship and project-based roles in Kenya.
Global Geothermal Alliance (GGA) : If you are looking for dialogue, cooperation, and coordinated action among geothermal stakeholders (governments, private sector, academia) to scale up geothermal energy
GRÓ Geothermal Training Programme (GRÓ GTP), Iceland / UNESCO

PRIVATE SECTOR & DEVELOPMENT PARTNERS

Helios Investment Partners: Invests in renewable projects, opportunities for youth in finance and sustainability.
African Clean Energy Impact Capital: Supports African clean energy entrepreneurs.
CHINT Group / Kaishan Group: Built the Soyasambu Geothermal Power Station, offering technical training opportunities.
Zhejiang Kaishan Renewable Energy Development: Provides global mentorship programs in geothermal engineering.
Tulu Moye Geothermal (Ethiopia): Offers internships and field experience in geothermal drilling and operations.

Please visit websites for more accurate information on opportunities. AEYA has not been sponsored by any of these organizations, we are only sharing information with you all.

CHALLENGES AND CONCERNS

ENVIRONMENTAL & SOCIAL CONCERNS

1.LAND USE

Geothermal energy projects take a lot of land to drill, a power plant, pipelines, and access roads. The case of Olkaria IV in Kenya brought to our attention that land use is a critical environmental and social issue. Over 1,000 Maasai people were relocated in August 2014 to allow geothermal expansion to take place on their ancestral land (Hughes , 2020).

Their original territory spanned 4,200 acres, but they were moved to just 1,200 acres, much of it less fertile and fragmented with gullies where their cattle sometimes fell and died.
Beyond displacement, geothermal development can fragment habitats, disrupt wildlife corridors, and degrade grazing land (Kong'ani et al., 2021). For pastoralist and Indigenous communities who depend directly on land for livelihoods and cultural identity, such changes are existential threats.

This raises a clear climate justice dilemma: while geothermal energy contributes to global progress by cutting carbon emissions, it also imposes local costs on communities who lose land, livelihoods, and cultural ties. Justice-oriented solutions require free, prior, and informed consent (FPIC), fair resettlement policies, and mechanisms to ensure communities share in the long-term benefits of the projects taking place on their land.

Sosian's Project Manager, Philemon Kimeli (Ole) speaking to colleague while overlooking the Menengai Caldera (Were, 2025).

CHALLENGES AND CONCERNS

ENVIRONMENTAL & SOCIAL CONCERNS

2. WATER USE

Every geothermal project begins with lots of water used for drilling, cooling, and re-injection. To illustrate this, a single drilling exercise can consume up to 2,000 liters of water per minute (Thornett, 2018) or the equivalent of two thousand one-liter bottles daily. This water consumption is especially alarming in places facing water shortage problems, like arid and semi-arid areas of Kenya, Ethiopia, and Djibouti.

Beyond volume, geothermal operations can pollute local water sources if wastewater is not carefully monitored. Communities that rely on these same sources for drinking, farming, and livestock could worry. For example, around Naivasha and Baringo, geothermal expansion intersects with water needed for agriculture and fragile ecosystems (Ibrahim Kipngeno Rotich et al., 2024).

This creates a climate justice dilemma: renewable energy helps reduce global carbon emissions, but can simultaneously deepen local inequalities if water access for communities is ignored. Justice-oriented solutions must include water-sharing agreements in how KenGen provides clean water to communities living near the Olkaria geothermal project. This led to a reduction of water-borne disease cases like cholera and typhoid.

Geothermal water tanks used for drilling, cooling, and re-injection (Kwamboka, 2025)

Nkatha & Mutia, 2018 (Nkatha & Mutia, 2018) studied geothermal liquid discharge from the Menengai field in 6 wells. From previous findings, it was established that sodium (Na), chloride (Cl) and fluoride (F) were elevated; mercury (Hg), chromium (Cr) and lead (Pb) were relatively high in some sampled wells. The results obtained showed no direct evidence of contamination from geothermal effluents, and all were within the safe standards for Kenya and the WHO.

CHALLENGES AND CONCERNS

ENVIRONMENTAL & SOCIAL CONCERNS

3. AIR QUALITY

Air quality at geothermal sites is also a point of contention. During exploration, drilling, and operation, gases trapped deep underground are released into the atmosphere. These include:

1. Water vapor and carbon dioxide (CO_2): Emissions are much lower than coal or gas plants, making geothermal a low-carbon energy source.
2. Hydrogen sulfide (H_2S): A gas with a distinctive rotten egg smell; at low doses, it is not harmful, but prolonged exposure can irritate the eyes and respiratory system.
3. Ammonia and methane: These are found in smaller amounts but still require monitoring.

In addition to gases, noise and odor pollution. The drilling rigs, trucks, and heavy machinery disrupt the peace of rural areas and create stress for local communities and wildlife. Vegetation clearance and fouling processes (removal of surface deposits during operations) can further disrupt the landscape. While this is a notable concern, the amount of pollution caused is very minimal and rarely causes harm, as the operating unit monitors the risks to ensure everything is contained.

Nyasaina Kwamboka reviewing safety signage outlining geothermal byproducts, hazards, and protective measures (Wachira, 2025)

Nkatha & Mutia, 2018 (Nkatha & Mutia, 2018) studied geothermal liquid discharge from the Menengai field in 6 wells. From previous findings, it was established that sodium (Na), chloride (Cl) and fluoride (F) were elevated; mercury (Hg), chromium (Cr) and lead (Pb) were relatively high in some sampled wells. The results obtained showed no direct evidence of contamination from geothermal effluents, and all were within the safe standards for Kenya and the WHO.

CHALLENGES AND CONCERNS

ENVIRONMENTAL & SOCIAL CONCERNS

4. SEISMIC ACTIVITY

Capturing geothermal energy involves deep drilling and the re-injection of large volumes of water underground. This process can occasionally trigger minor earthquakes, known as induced seismicity. While usually small, these tremors may still damage homes and unsettle communities that are often unaware of the risks. Even limited ground movement can cause fear and insecurity, especially among people living in poorly built houses or on unstable land. Addressing this requires transparent risk assessments, community awareness programs, and fair compensation frameworks, ensuring that local residents do not shoulder the costs of seismic risks created in pursuit of national energy goals.

Eng. Festus Mbae showing the grain dryer in the direct-use (Were, 2025)

Geothermal drilling and reinjection activities can alter underground pressure balances, leading to land instability and seismic effects. Achieng and Mwaniki examined the Menengai Geothermal Field (MGF) using satellite radar (Sentinel SNAP and TOPSAR) to assess deformation and subsidence between 2015 and 2021. Their findings revealed measurable ground shifts, with uplift and subsidence recorded at 2.4 cm in 2016, 9 cm in 2017, 8 cm in 2018, 5 cm in 2019, 7 cm in 2020, and 3 cm in 2021. The northeastern portion of MGF exhibited the greatest fault activity, attributed to both tectonic processes and geothermal drilling. GPS data validated the displacement maps, confirming that geothermal well development has contributed to uneven topography in the region. The study concluded that continuous monitoring is essential to track deformation patterns and better understand the combined impacts of drilling, reinjection, and natural tectonic forces on land stability (Achieng & Mwaniki, 2023)

Financing a Geothermal Project

Geothermal energy projects require a fortune worth millions of dollars.

To understand financing a geothermal project, we must understand 3 key terms

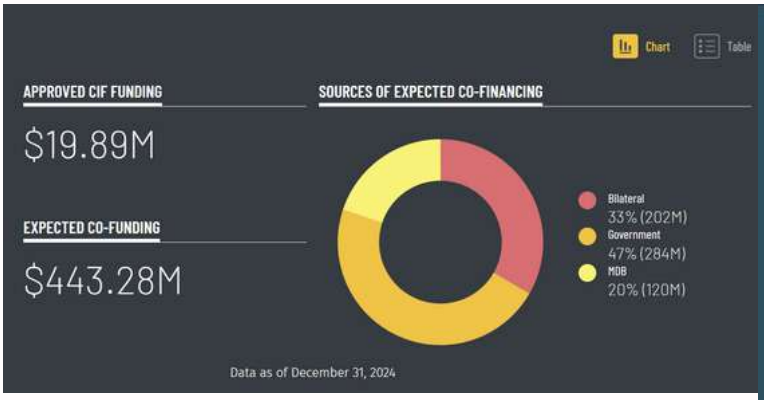
IPP **(Independent Power Producer)** - A private company that builds and operates a power plant, then sells electricity to the grid or directly to consumers.

PPA **(Power Purchase Agreement)** - A long-term contract between a power producer (like an IPP) and a buyer (often a utility company such as KPLC), guaranteeing that the electricity produced will be purchased at an agreed price.

PPP **(Public-Private Partnership)** - A collaboration between government and private companies to finance, build, and operate major projects, sharing both risks and benefits.

Equally, there are seven levels of production that show where the Geothermal Development Costs fall, this is best outlined by the authors of Geothermal Power Plants Project Finance through Public-Private Partnership: (Nyokabi et al. 2023). The convectional costs include:

1. **Exploration costs** – Include the cost of drilling exploration wells, desktop data review, detailed surface study (Geophysics, Geology, and Geochemistry surveys), and infrastructure development.
2. **Appraisal costs** – This stage typically includes drilling 6–9 appraisal wells and conducting a desktop study with reservoir simulation and preliminary plant design.
3. **Production drilling costs** – Entail drilling to provide sufficient steam to operate a specific size of a power plant at full capacity and reinjection wells.
4. **Power plant construction** – The cost of power plants varies even for plants of the same size because they are designed to correspond to the resource attributes, in particular, the turbine inlet pressure.
5. **Operation and maintenance (O&M) costs** – Include staff, administrative, and cost of spares, plant inefficiency, reservoir management costs, and cost of capital associated with increased working capital. Ongoing expenses are needed to keep the plant functioning effectively.
6. **Plant inefficiency cost** – Geothermal power plants suffer failures and breakdowns, too. They require inspection, repairs, and rehabilitation.
7. **Steam field management cost** – Steam fields necessitate close monitoring during steam production to forestall serious steam declines, cold flow invasion, scaling, and other adverse effects.

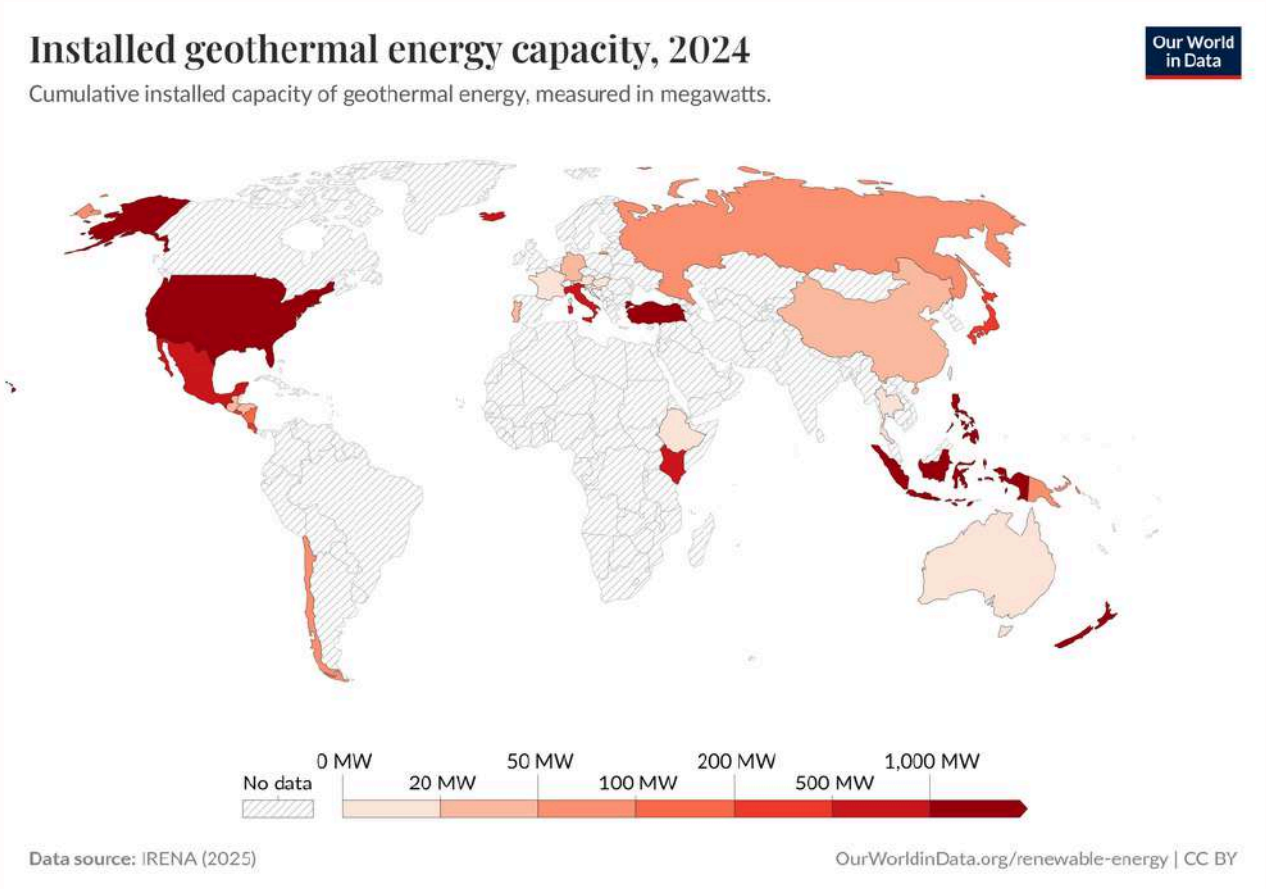


GENERAL INFORMATION	
TITLE	Menengai Geothermal Development Project
PROJECT ID	XSREKE012A
COUNTRY	Kenya
REGION	Sub-Saharan Africa
PROGRAM	Scaling Up Renewable Energy Program in Low Income Countries (SREP)
PROGRAMMING TYPE	IP
STATUS	Closed

FINANCING	
APPROVED AMOUNT (USD MILLION)	25.00
FINANCIAL PRODUCT (USD MILLION)	Non-Grant : 5.38 Grant : 14.51
CIF FUNDING	19.89
CO FINANCING	443.28
COMMITTEE APPROVAL DATE	11/21/2011
MDB APPROVAL DATE	12/16/2011
CLOSURE DATE	08/31/2020
MDB / IMPLEMENTING PARTIES	African Development Bank
SECTOR TYPE	Public Sector

According to the Climate Investment Funds (CIF), the total estimated cost of the Menengai Geothermal Project amounts to approximately USD $443.28 million (about KES 58.3 billion), illustrating the substantial capital requirements outlined in the seven stages of geothermal project financing.

Financing a Geothermal Project



In Kenya, geothermal projects have thrived largely because of Public-Private Partnerships (PPPs) and we can apply this to other countries in the African Rift

Public-Private Partnerships is a financial model where the **government and private investors share both the risks and the rewards**. This model has made it possible to mobilize the massive funding such projects require, while ensuring accountability and efficiency.

CASE STUDY: The Menengai Geothermal Development Project is planned in five phases to deliver 465MW of geothermal steam. In the first phase, three independent power producers (IPPs), QPEA GT Menengai Limited, Sosian Menengai Geothermal Power Limited, and Orpower Twenty-Two Limited, are each building a 35MW plant (totaling 105MW).
The initial cost of the development is paid by the state-owned Geothermal Development Company (GDC) through Public- Private Partnership (PPP) model where the subsidies of early development are paid by the state owned company, and the financing, construction, and operation of plants is done by the independent power producers (IPPs). The electricity produced is sold to KPLC through Power Purchase Agreements (Nyokabi et al., 2023).Expanding the use of PPPs across the East African Rift System could unlock even more geothermal potential, turning the region into a hub of renewable, reliable, and sustainable energy.

Due to this strategic financing approach, Kenya has emerged as a world leader in geothermal energy by ranking first in Africa and sixth globally in installed capacity.

Replicating and improving Kenya's Public–Private Partnership (PPP)and Policy model across other African Rift countries could enable sustainable project financing and policy implementation, positioning the continent to lead the way in geothermal innovation and advance toward energy sovereignty.

ACTIVITY SECTION

GROUP DISCUSSION QUESTIONS

- Do you think it is a smart decision for Africa to use fossil fuels as a baseload energy when we have various options to renewable energy?

- In rural parts of Africa, over 600 million people still lack access to electricity. Can geothermal realistically be scaled to address energy poverty in remote areas, or is it better suited to powering industrial and urban centers? Bonus: In what ways could we implement other sources of renewable energy to provide electricity in rural areas?

- Only a handful of African countries have clear geothermal policies. What could we do to push for a continental geothermal strategy?

DEBATE PROMPT: "IS GEOTHERMAL THE FUTURE OF AFRICA'S CLEAN ENERGY?"

REFERENCES

Abegaz K. MID-TERM REVIEW of the UN ENVIRONMENT GEF FUNDED PROJECT "African Rift Geothermal Development Facility (ARGeo) Project.; 2017. Accessed August 22, 2025. https://open.unep.org/docs/gef/MTE/2119_2017_MTR_.pdf

Achieng, J., & Mwaniki, M. (2023). Investigating Ground Deformation and Possible Causative Factors in Menengai, Nakuru. International Journal of Geosciences, 14(11), 1100–1122. https://doi.org/10.4236/ijg.2023.1411056

Abdi, A. M., Murayama, T., Shigeo Nishikizawa, & Kultip Suwanteep. (2024). Social acceptance and associated risks of geothermal energy development in East Africa: Perspectives from geothermal energy developers. Clean Energy. https://doi.org/10.1093/ce/zkae051

Adityatama, D., Purba, D., Uhammad, F., Agustino, V., Wiharlan, H., & Pasmeputra, K. (2020). Slimhole drilling overview for geothermal exploration in Indonesia: Potential and challenges. https://pangea.stanford.edu/ERE/db/GeoConf/papers/SGW/2020/Adityatama.pdf

Brown, W. (2022, December). Kenya taps the earth's heat. IMF. https://www.imf.org/en/Publications/fandd/issues/2022/12/country-case-kenya-taps-the-earth-heat

Burnside, N., Montcoudiol, N., Becker, K., & Lewi, E. (2021). Geothermal energy resources in Ethiopia: Status review and insights from hydrochemistry of surface and groundwaters. WIREs Water, 8(6). https://doi.org/10.1002/wat2.1554

California Energy Commission. (2025). Types of geothermal power plants. California Energy Commission. https://www.energy.ca.gov/data-reports/energy-almanac/data-renewable-energy-markets-and-resources/types-geothermal-power

Cariaga, C. (2022, July 14). GDC pilot testing direct use applications of geothermal energy. Think GeoEnergy - Geothermal Energy News. https://www.thinkgeoenergy.com/gdc-pilot-testing-direct-use-applications-of-geothermal-energy/

Cariaga, C. (2025, January 20). ThinkGeoEnergy's top 10 geothermal countries 2024 – power. Think GeoEnergy - Geothermal Energy News. https://www.thinkgeoenergy.com/thinkgeoenergys-top-10-geothermal-countries-2024-power/

Climate Investment Funds. (2020). Menengai Geothermal Development Project. Cif.org. https://www.cif.org/projects/menengai-geothermal-development-project

Counter Balance. (2020). Heating up: The negative impact of development banks supporting geothermal industry in Kenya. https://counter-balance.org/news/heating-up-the-negative-impact-of-development-banks-supporting-geothermal-industry-in-kenya

Craig, T. J., & Jackson, J. A. (2021). Variations in the Seismogenic Thickness of East Africa. Journal of Geophysical Research Solid Earth, 126(3). https://doi.org/10.1029/2020jb020754

Fawzy, A. (2020, May 2). Desalination Using Renewable Energy. ResearchGate. https://doi.org/10.13140/RG.2.2.36175.02723

Geiger, B. (2019, November 11). Explainer: Earth layer by layer. Science News Explores. https://www.snexplores.org/article/explainer-earth-layer-layer

Geothermal Development Company. (2024, May 20). Direct use. GDC. https://www.gdc.co.ke/direct-use/

Geothermal Development Company. (2025). Menengai. Geothermal Development Company. https://www.gdc.co.ke/menengai/

Geothermal Rising. (2022, April 15). How geothermal power plants provide clean energy. Geothermal.org. https://geothermal.org/our-impact/blog/how-geothermal-power-plants-provide-clean-energy

Global Volcanism Program. (2025). St. Helens (321050) in [Database] Volcanoes of the world (v. 5.3.1; 6 Aug 2025). Smithsonian Institution. https://doi.org/10.5479/si.GVP.VOTW5-2025.5.3

Global Volcanism Program. (n.d.). Menengai. Smithsonian Institution | Global Volcanism Program. https://volcano.si.edu/volcano.cfm?vn=222060

Government of Kenya. (2019). Energy Act, No. 1 of 2019. NATLEX. https://natlex.ilo.org/dyn/natlex2/r/natlex/fe/details?p3_isn=109334

Greiner, C., Klagge, B., & Owino, E. A. (2023). The political ecology of geothermal development: Green sacrifice zones or energy landscapes of value? Energy Research & Social Science, 99, 103063. https://doi.org/10.1016/j.erss.2023.103063

Gupta, S. K., Dwivedi, V., Yadav, A., & Sharma, A. (2010, November 19). Geothermal energy resources and utilization, in India: An eco-friendly approach for sustainable development. ResearchGate. https://www.researchgate.net/publication/331222873_Geothermal_Energy_Resources_and_Utilization_in_India_An_Eco-Friendly_Approach_for_Sustainable_Development

Hughes , L. (2020). Heating up: The negative impact of development banks supporting.... Counter Balance. https://counter-balance.org/news/heating-up-the-negative-impact-of-development-banks-supporting-geothermal-industry-in-kenya?

Illuminem. (2023, May 28). Harnessing the earth's energy: Pros and cons of geothermal power plants. Illuminem.com. https://illuminem.com/illuminemvoices/harnessing-the-earths-energy-pros-and-cons-of-geothermal-power-plants

REFERENCES

Ibrahim Kipngeno Rotich, Chepkirui, H., Musyimi, P. K., & Gideon Kipruto. (2024). Geothermal energy in Kenya: Evaluating health impacts and environmental challenges. Energy Sustainable Development/Energy for Sustainable Development, 82, 101522–101522. https://doi.org/10.1016/j.esd.2024.101522

International Renewable Energy Agency (IRENA). (2018). Installed geothermal energy capacity. Our World in Data. https://ourworldindata.org/grapher/installed-geothermal-capacity

Jaffe, R. L., & Taylor, W. (2018). The physics of energy. Cambridge University Press.
Kenya News Agency. (n.d.). GDC woos investors in geothermal direct use. Kenya News Agency. https://www.kenyanews.go.ke/gdc-woos-investors-in-geothermal-direct-use/

KfW Development Bank. (2016). Kenya is hot for geothermal energy. Kfw-Entwicklungsbank.de. https://www.kfw-entwicklungsbank.de/SDG-portal/SDG-7/Geothermal-Energy-Kenya/

Klempa, M., Bujok, P., Struna, L. K., & Pinka, J. (2024). Fundamentals of onshore drilling. Geologie.vsb.cz. http://geologie.vsb.cz/DRILLING/drilling/theory.html

Kong'ani, L. N. S., Wahome, R. G., & Thenya, T. (2021). Variety and management of developmental conflicts: the case of the Olkaria IV geothermal energy project in Kenya. Conflict, Security & Development, 21(6), 781–804. https://doi.org/10.1080/14678802.2021.2000806

Kumar, S., Kumar Gupta, S., & Rawat, M. (2020). Resources and utilization of geothermal energy in India: An eco – friendly approach towards sustainability. Materials Today: Proceedings, 26, 1660-1665. https://doi.org/10.1016/j.matpr.2020.02.347

Mibei, G. (2016). Geothermal exploration of the Menengai geothermal field. https://rafhladan.is/bitstream/handle/10802/13963/UNU-GTP-SC-23-0504.pdf?sequence=1

Mondejar, M. E., & Chamorro, C. R. (2017, January 1). Geothermal power technologies. In M. A. Abraham (Ed.), Encyclopedia of sustainable technologies (pp. 233-256). Elsevier. https://www.sciencedirect.com/science/article/abs/pii/B9780124095489100958

NATLEX - Kenya - Energy Act, No. 1 of 2019. (2019). Ilo.org. https://natlex.ilo.org/dyn/natlex2/r/natlex/fe/details?p3_isn=109334

Nyokabi1, J., Kilangi2, J., Mathu3, L., Mwakugu4, S., Kumbuso, J., & Nyoni5. (2023). Geothermal Power Plants Project Finance through Public-Private Partnership: A case of Africa. https://www.worldgeothermal.org/pdf/IGAstandard/WGC/2023/14.pdf

Open Energy Information. (n.d.). Binary cycle power plant. Openei.org. https://openei.org/wiki/Binary_Cycle_Power_Plant

Richter, A. (2016a, November 9). AfDB: Geothermal plays an important role for Africa beyond electricity. Think GeoEnergy - Geothermal Energy News. https://www.thinkgeoenergy.com/afdb-geothermal-plays-an-important-role-for-africa-beyond-electricity/

Richter, A. (2016b, December 23). KenGen buys three additional rigs to cut cost in imminent geothermal drilling campaign. Think GeoEnergy - Geothermal Energy News. https://www.thinkgeoenergy.com/kengen-buys-three-additional-rigs-to-cut-cost-in-imminent-geothermal-drilling-campaign/

Rojas, F. (2015, August 31). GDC pushes forward with pilot project on direct use. Think GeoEnergy - Geothermal Energy News. https://www.thinkgeoenergy.com/gdc-pushes-forward-with-pilot-project-on-direct-use/

Rotich, I. K., Chepkirui, H., Musyimi, P. K., & Kipruto, G. (2024). Geothermal energy in Kenya: Evaluating health impacts and environmental challenges. Energy for Sustainable Development, 82, 101522. https://doi.org/10.1016/j.esd.2024.101522

The Coalition for Human Rights in Development. (2025, March 31). Kenya: The true impact of the AfDB-funded Menengai geothermal project. https://rightsindevelopment.org/news/kenya-menengai-geothermal/

ThinkGeoEnergy. (2023, June 15). RFP – Geothermal direct use investments in Menengai, Kenya. ThinkGeoEnergy. https://www.thinkgeoenergy.com/rfp-geothermal-direct-use-investments-in-menengai-kenya/

ThinkGeoEnergy. (2024). GDC planning geothermal industrial park at Menengai, Kenya. World-Energy. https://www.world-energy.org/article/39460.html

Thornett, R. C. (2018). Kenya's Energy Quandary, Geothermal development in the Kenyan Rift Valley shows that even renewable energy can be unsustainable in fragile environments. Earth Island Journal; An Earth Island Institute Publication. https://www.earthisland.org/journal/index.php/magazine/entry/kenyas_energy_quandary/

United Nations. (2024). Decoding Africa's energy journey: Three key numbers. Un.org. https://unsdg.un.org/latest/stories/decoding-africa%E2%80%99s-energy-journey-three-key-numbers

Utami, A., Aji, N., Fadyah, A., Ghifari, A., Anam, M. B., Ramadhani, S., Rasyid, F. H., & Maulana, R. R. (2020). Geothermal energy solid waste management: Source, type of waste, and management. AIP Conference Proceedings, 2245(1). https://doi.org/10.1063/5.0007299

Wamanji, E. (2025, July 8). Geothermal diplomacy: Kenya's soft power from a heated earth. The Geo Blog GDC. https://www.gdc.co.ke/blog/geothermal-diplomacy-kenyas-soft-power-from-a-heated-earth/